Reply to a Comment on "the Role of Dimensionality in the Stability of a Confined Condensed Bose Gas"

Luca Salasnich [1]

Dipartimento di Matematica Pura ed Applicata,
Università di Padova, Via Belzoni 7, I 35131 Padova, Italy
Istituto Nazionale di Fisica Nucleare, Sezione di Padova,
Via Marzolo 8, I 35131 Padova, Italy
Istituto Nazionale per la Fisica della Materia, Unitá di Milano,
Via Celoria 16, 20133 Milano, Italy

Abstract

As pointed out by the authors of the comment quant-ph/9712046, in our paper quant-ph/9712030 we studied in detail the *metastability* of a Bose–Einstein Condensate (BEC) confined in an harmonic trap with zero–range interaction. As well known, the BEC with attractive zero–range interaction is not *stable* but can be *metastable*. In our paper we analyzed the role of dimensionality for the *metastability* of the BEC with attractive and repulsive interaction.

PACS Numbers: 03.75.Fi, 05.30.Jp

[1]E–Mail: salasnich@padova.infn.it

In a recent paper[1)] we studied the ground–state stability of a Bose–Einstein condensate (BEC) confined in an harmonic trap with repulsive and attractive zero–range interaction by minimizing the energy functional of the system[3)] given by

$$\frac{E}{N} = \int d^3\mathbf{r}\, \frac{\hbar^2}{2m}|\nabla\Psi(\mathbf{r})|^2 + V_0(\mathbf{r})|\Psi(\mathbf{r})|^2 + \frac{BN}{2}|\Psi(\mathbf{r})|^4\,, \qquad (1)$$

where $\Psi(\mathbf{r})$ is the wavefunction of the condensate, $V_0(\mathbf{r}) = m\omega^2\mathbf{r}^2/2$ is the external potential of the trap, and $B = 4\pi\hbar^2 a_s/m$ is the scattering amplitude (a_s is the s–wave scattering length). Obviously N is the number of Bosons of the condensate.

In their comment[2)] Brosens, Devreese and Lemmens demonstrate the well-known result (implicit in our paper) that the BEC is unstable if there is more than 1 Boson.

It is important to stress that in our paper[1)] we studied not only the *stability* but also the *metastability* of the BEC by varying the spatial dimension of the system. In the case of repulsive interaction the system is stable and the BEC mean radius grows by increasing the number of Bosons. In the case of attractive interaction there is a metastable regime and the BEC mean radius decreases by increasing the number of Bosons: to zero if the system is one–dimensional and to a minimum radius, with a maximum number of Bosons, if the system is three–dimensional.

In the second part of their comment, the authors of Ref. 2 claim that replacing the zero-range interaction by a short-range attractive interaction lifts the instability, and leads to a pronounced clustering, by which the particles leak out of the condensate. This is an interesting result and probably

correct.

Acknowledgments

The author is grateful to Prof. A. Parola and Prof. L. Reatto for stimulating discussions.

References

1. L. Salasnich, quant-ph/9712030, to be published in Mod. Phys. Lett. B (98).

2. F. Brosens, J.T. Devreese and L.F. Lemmens, quant-ph/9712046.

3. E.P. Gross, Nuovo Cimento **20**, 454 (1961); L.P. Pitaevskii, Sov. Phys. JETP **13**, 451 (1961).